Localized frequency difference EIT for lung tumour monitoring

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Abstract: This paper presents a localized frequency difference EIT (fdEIT) algorithm for lung tumour monitoring. A simulated fdEIT is used to provide tomographic images of lung tumour by assuming local area of tumour is known. Limited region technique is applied to extract important information out of region of interest. Further experimental phantom based tests will be carried out to validate the proposed method.

1 Introduction

Electrical impedance tomography (EIT) is a fast and cost-effective technique to provide tomographic conductivity image of a subject from boundary current-voltage data. EIT has various potential applications in medical area, such function monitoring in lung EIT imaging. In traditional lung EIT imaging dynamical images of entire lung is generated to clinically investigate aspects of respiratory functions.

In this paper we present hypothesis of using lung EIT imaging for lung tumour monitoring. The lung tumour imaging using EIT is proposed during cancer treatment process such as radiation therapy. This poses some major challenges including: spatial resolution for lung tumour imaging is far more challenging than imaging entire lung itself; time difference imaging may not work as the reference image of the patient without lung tumour may not exist. Additionally imaging lung interior may become very challenging due to its low electrical conductivity, so a complex impedance imaging may be needed. Traditional EIT reconstruction uses time difference imaging technique. However, time difference EIT may not be useful for monitoring lung tumour behaviour as it is difficult to obtain background data of lung while the tumour has already consisted in the region. This problem may be solved by using frequency difference reconstruction [1] as it only requires measurement data in two different frequencies. This will work only if we can find two frequencies that the lung tumour has different electrical conductivity (or permittivity) compare to normal tissues. The difficulty is that lung itself has different frequency response compared to chest tissues [3]. In this case, both data from thorax and lung are treated as background data. When lung tumour is moving or changing, conductivity changes due to frequency change can produce conductivity image of lung tumour. EIT for lung tumour monitoring can take advantage of a priori information from diagnostic X-Ray CT images, so a localised EIT can be used to further enhance the spatial resolution.

2 Methods

In this paper, we use a frequency difference EIT (fdEIT) algorithm to produce lung tumour image. Using a weighted fdEIT algorithm [2] is essential to produce satisfying fdEIT images. Patients specify model can be developed using diagnostic CT images which can have the tumour position located. Limited region tomography (LRT) method is added for extracting the useful information out of the whole boundary. An FEM model of 16 electrodes EIT human chest model is created and image of lung is reconstructed (Figure 1). Figure 2 shows a simulation of lung tumour using a human lung mesh model. Reconstructions are done using adjacent current pattern. Background data includes thorax and two lungs with tumour in one single frequency, secondary data includes the same tumour but assuming with different frequency response. Reconstruction shows tumour images under fdEIT and LRT assumptions.

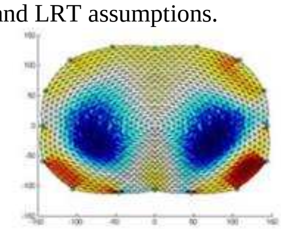

Figure 1: Reconstruction of simulated lung with 16 electrodes chest model.

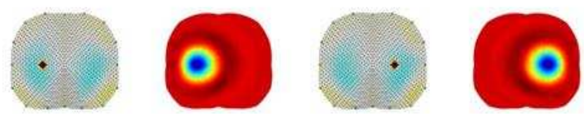

Figure 2: True images of lung tumour and simulation results of reconstructing tumour in a human lung structure.

The idea of localising the image is that assuming the tumour position can be obtained by CT scan, a specific region of interest (ROI) can be created by resizing the Jacobian matrix and resolving the inverse problem only on limited region.

3 Conclusions

This paper proposes a localized weighted frequency difference EIT technique for lung tumour imaging. Localize technique is employed for extracting useful information out of the region of interest. Phantom based experimental results will be presented in conference presentation. Although, this is an extremely challenging imaging tasks, but we hope that we will take advantage of recent momentum in conventional EIT lung imaging to make progress.

References

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